The Mariculture Program of the University of Texas at Austin, Port Aransas Marine Laboratory, was funded in part by the generosity of the following:

Sid W. Richardson Foundation

Caesar Kleberg Foundation for Wildlife Conservation

James R. Dougherty Foundation

Game Conservation International

Special Appropriation by U.T. Board of Regents

Texas A&M University, Sea Grant College Program

The staff of the Mariculture Program is thankful and honored by this support.

Photo 1 - Research Staff

Front row left to right: Dr. W. Wofford, T. Ricks, Dr. C. Arnold, Dr. W. Lee

Middle row: S. Holt, Dr. P. Thomas, J. Trant

Back row: N. Wohlschlag, N. Brown, J. Gourley, Dr. H. Lin, Dr. J. Holt, J. Munoz

MARICULTURE PROGRAM REPORT 1981-1982

INTRODUCTION

The mariculture program of the University of Texas, Port Aransas Marine Laboratory is a team approach to the study of marine finfish which are native to Texas coastal waters. Researchers in the mariculture program (photo 1) are currently conducting studies on the following: spawning, eggs and larvae, natural habitats, fingerling production and grow-out systems, reproductive physiology, and nutrition. These studies are designed to answer basic biological and technical questions which must be resolved before finfish can be grown in controlled environments. Although our major emphasis is on red drum, other finfish such as spotted seatrout, red snapper, and pompano are also being studied.

The following is a report of our research activities and accomplishments during the year August 1981-82.

SPAWNING PROJECT

Red drum were first induced to spawn naturally in captivity at the Port Aransas Lab in 1975 using a temperature-photoperiod method.

Redfish caught in the wild were transported to laboratory spawning tanks where they were checked for parasites and sexed (Photo 2) and then subjected to a temperature-photoperiod regime corresponding to the season in which they were captured. The light-dark cycle and the water temperature of the spawning tanks were manipulated so the fish were sequentially exposed to four different seasons. Each seasonal regime was

Photo 2.

Redfish being checked for parasites and sexed.

maintained for 45 days according to the following protocol:

	Light	Dark	Temperature
Spring	12 h	12 h	21°C
Summer	15 h	9 h	26°C
Fall	12 h	12 h	21°C
Winter	9 h	15 h	16°C

When the spawning conditions (fall season) were reached they were maintained until spawning began. During the first spawning period 52 spawns occurred over a period of 72 days and an estimated 60 million fertilized eggs were produced by 3 females and 3 males. Since that initial spawning other research groups have successfully spawned red drum using the temperature-photoperiod method.

Preliminary studies indicated that spawning could be slowed or stopped by decreasing the temperature. Therefore after spawning was initiated with 3 females and 2 males we began raising and lowering the temperature while holding the photoperiod constant. During the first two months spawning was frequent but when the temperature was lowered from 23 to 21°C in 3 days, spawning ceased until the temperature started to rise again. Thirty days later the experiment was repeated and again spawning ceased after the temperature decreased. Temperature control was lost and the temperature dropped to 17°C. At this low temperature spawning did not resume until the temperature increased to 22°C. There has been only one spawn at 20°C or lower.

We have continued to manipulate the water temperature, and spawning has continued for the past 25 consecutive months resulting in 173 spawns. Spawning ceased during the month of February 1982 when the heater

malfunctioned and the temperature did not go above 18°C. Spawning resumed in March after the temperature reached 22°C.

The size of the spawns have ranged from 10 thousand to 2.5 million fertilized eggs/spawn. The percent fertilization and hatch rate have not changed and the brood stock appear to be in healthy condition. The last spawn was September 12, 1982 and there is no indication spawning is about to cease.

EGG & LARVAL STUDIES

Another area essential to understanding the life cycle of marine fish and possibly the most difficult to study is the early life history - the eggs and larval stages. We are developing techniques and methodologies to analyze the effects of environmental factors on fish eggs and larvae. This work has emphasized the development of successful rearing systems by identifying effects of salinity and temperature, food and feeding rates, and stocking densities on the survival and growth of larvae. We routinely have greater than 95% egg hatching, and we have gone from 0-10% survival through the larval stage (14 days) up to a regular survival rate of 35-50% and a phenomenal 80% survival in some few cases. In our temperature - salinity studies we found highest percentage hatch occurred at 25-30 o/oo. This is close to the salinity of the spawning tanks. There was no difference in larval development at salinities of 15-30 o/oo.

Successful development of the larvae was limited to temperatures above 20°C (68°F). The time spent in the yolk-sac stage is temperature dependent; ranging from 40 hours at 30°C to 85 hours at 20°C. With low temperature, development and probably metabolism were slowed to the extent that growth and even mortality were delayed.

Table 1. Length-weight relationship of red drum larvae (Sciaenops ocellata) at 24°C.

	Days					
	1	3	5	7	9	11
Standard length (mm)	2.6	2.69	2.68	2.86	3.28	3.65
1 S.D.	0.11	0.06	0.08	0.19	0.14	0.32
No. of measurements	17	15	15	19	15	15
Dry weight (µg)	22.97	20.75	14.68	27.96	42.83	54.37
1 S.D.	4.08	2.15	0.20	6.70	3.66	6.07
No. of groups	3	3	3	6	3	3

Table 2. Length-weight relationship of red drum larvae (Sciaenops ocellata) at 28°C.

	Days				
	1	3	5	7	9
Standard length (mm)	2.5	2.6	2.6	3.2	3.2
1 S.D.	0.06	0.06	0.10	0.14	0.14
No. of measurements	15	15	15	15	15
Dry weight (µg)	17.43	17.89	15.46	32.90	48.95
1 S.D.	6.30	1.23	5.28	7.17	13.58
No. of groups	4	4	4	4	4

The few fish that survived two weeks in 20°C were inactive, were not seen catching prey, and they grew very slowly. Larvae raised at higher temperatures actively attacked and ate prey as soon as it was introduced to the chamber.

Other important factors influencing larval mortality are food and feeding relationships and the influence of environmental parameters on these processes. We have found that a critical phase in larval development occurs at the beginning of active feeding. Current research to analyze feeding problems involves an investigation of larval survival in relation to food density and the environmental factors temperature and photoperiod, and ammonia, nitrite and nitrate.

Length, Weight, and Temperature Relationships

Fertilized eggs of red drum were incubated and grown at two temperatures (24 and 28°C) and at a salinity of 30 o/oo. Hatched larvae were raised according to methods slightly modified from Holt et al. (1981), and at a density of 70-100/l. The larvae remained unfed for the first two days, and then were provided with rotifers of < 93 μm at days 3-5 and of mixed size at days 6-8, ad lib. Newly hatched Artemia nauplii were added thereafter. Fifteen fish larvae were sampled every other day for measurements.

Preliminary results shown in Tables 1 and 2 suggest that the growth pattern of fish raised at 24 and 28°C did not differ at the early stage of their life cycle. At 28°C, the weight of larval fish declined slightly during the first 5 days post-hatch. The average individual dry weight dropped from 17.43 to 15.46 g. After day 5, fish grew extremely fast (> 8 μg/day). It is believed that the transition from the inactive

yolk-sac to the active feeding stage must occur at day 5 or 6 and the size at the onset of active feeding is about 2.7 mm. Before that time feeding activity was negligible. In terms of length, fish grew in a similar way, but varied at a smaller amplitude when compared with changes in the dry weight.

Effects of temperature on fish larval length were not evident for the two groups tested. They were about 3.2 mm at day 9. In contrast, fish weight increased at a greater rate at 28°C then at 24°C after the yolk-sac stage. For example, at day 9 fish at 28°C attained a mean weight of 48.95 g while at 24°C they weighed 42.83 g.

Feeding Behavior of Juvenile Red Drum (Laboratory reared vs wildcaught)

A field population of red drum and one of the food prey Mysidopsis almyra (Mysids) were collected from seagrass beds adjacent to the Aransas Pass lighthouse in November 1981. Another food species tested (Parhyale hawaiensis Amphipoda) was from a stock culture maintained in the laboratory.

Both field and laboratory-raised fish were acclimated to the same conditions for 2 days before the experiment; they were kept in 1 µm filtered seawater (30%), at 22°C, and fed 48-h old Artemia nauplii. At day 3, fish were individually transferred to a one-liter jar containing 15 of either amphipods or mysids. The jars were then mounted on a ferris wheel and rotated through a waterbath (22°C) for 6 h under light.

Since prey size, especially the maximum width, was believed to be a very important factor affecting the feeding behavior of marine fish, the size of the two prey organisms employed in this experiment was determined, and summarized in Table 3. Mysids were slightly larger than amphipods in

Table 3. Size characteristics of juvenile red drum, amphipod, and mysid.

	No. of observations	Average length (mm)	S.D.	Dry weight (mg)	S.D.	Average width (mm)	S.D.
S. ocellata							
field	10	17.7	1.46	21.1	5.3	-	-
laboratory	10	22.2	0.57	45.3	3.6	-	-
P. hawaiensis	15	4.12	0.49	0.67	0.13	0.81	0.08
M. almyra	15	5.90	0.31	0.82	0.13	0.91	0.07

Table 4. Consumption rates (prey/fish/h) of amphipod and mysid by juvenile red drum.

	P. hawaiensis	No. of observations	S.D.	*M. almyra*	No. of observations	S.D.
S. ocellata						
field	0.36	8	0.19	0.46	8	0.12
laboratory	1.37	8	0.36	1.44	8	0.32

terms of either length or weight. Both preys were consumed equally by natural and laboratory reared populations. The field red drum with an average size of 17.7 mm was able to ingest amphipods at a rate of 0.36 individuals/hour and mysids at a rate of 0.46 individuals/hour.

Fish raised in the laboratory consumed amphipods and mysids at a rate of 1.37 individuals/h and 1.44 individuals/h respectively. The higher feeding rates were obviously related to its larger size compared to that of the field fish (Table 4). It is also interesting to note that laboratory fish were only 4.5 mm larger, yet consumed 3 more preys than the other group.

Future Studies

We shall continue working on the feeding biology of red drum larvae, including determination of ingestion rates of rotifer, changes in O:N ratios during the early life stage, respiration rates, and relationship between fish and prey size. Equipment to be employed includes the Gilson Differential Respirometer and Population Counting Accessory, which were recently purchased.

NATURAL HABITAT STUDIES

One of the objectives of this study was to determine the distribution of young red drum in a variety of shallow water seagrass meadows to determine the influence of habitat structure on juvenile red drum abundance.

A series of samples were taken in shallow water seagrass meadows which differed from each other in height of shoalgrass (Halodule wrightii)

plants, blade density, and water depth. Other samples were taken in shallow areas with no vegetation and at sites where vegetated and non-vegetated areas were adjacent and formed a distinct edge with the seagrass meadow.

No young red drum were caught on the non-vegetated bottom, whereas at least a few red drum were taken at all vegetated sites. Densities of red drum (6 to 27 mm standard length) averaged 0.10 to 0.80 individuals per m^2. No differences in red drum abundance were found among the various vegetated sites, but significantly more red drum were captured at the edge sites than at any of the homogeneously vegetated sites. It appears that heterogeneous seagrass meadows support higher densities of red drum than homogeneous meadows. These results will be further tested this year to verify the validity of these findings and determine their full implication in the early life history of red drum.

Another objective was to determine if seatrout eggs and larvae could be found in sufficient density to determine time and spawning location. The results were very positive. Spotted seatrout eggs were found in the immediate area where running-ripe female spotted seatrout were simultaneously being caught. This confirmed that the seatrout were actually spawning in shallow grassbed areas. Identification of these eggs was provided by hatching the eggs and raising the young fish in the laboratory until they were large enough to be positively identified. A series of samples taken in this area over a 24 hr period showed that most spawning takes place near dusk with little or no spawning activity during the rest of the day. Hatching occurred in 18-20 hours at the ambient seawater temperature of 27°C.

Investigations were begun to determine the feasibility of using otoliths (inner ear bones) to determine daily age of young red drum. It has been shown that differential growth rate over the diurnal cycle produces marks on the otoliths and other body structures, which can be read much like rings on tree trunks. Knowing the exact daily age of young red drum would allow accurate calculation of their growth rate and movement patterns. The initial work involved counting otolith rings from known age larvae raised in a greenhouse to determine the age at which the initial ring is laid down and to judge the amount of variability to expect in ring counts. Although the results of this investigation are not final it is clear that otolith rings can be used to age red drum to a size of at least 10 mm standard length.

Future work is planned to apply this method to age naturally occurring populations of young red drum. This will allow a comparison of the growth and development of lab reared fish under varying controlled conditions to growth and condition of naturally occurring fish.

FINGERLING PRODUCTION AND GROW OUT SYSTEM

The red drum fingerlings are produced in 6m (20') diameter x 0.9m (3') high, fiberglass round tanks. The tank is filled with filtered and sterilized sea water of the same salinity as the spawning tanks. It is fertilized with 200 g ammonia sulphate and 100 g of super phosphate, inoculated with green algae and allowed to grow for 6 days. Rotifers are

introduced and 2 days later the fertilized eggs are placed in the tanks. Rotifiers are added to the tank daily for 10 days. Newly hatched brine shrimp nauplii are started on day 9 after hatch and fed to the larvae for 9 days. A floating food made from ground shrimp is fed for the next 20 days. The fingerling are harvested between 30-40 days at an average size of 31 mm and .75 g.

GROWTH OF LARVAE AND FINGERLINGS

egg to 2 weeks	.35 mm/day
2 weeks to 4 weeks	.5 mm/day
4 weeks to 6 weeks	1.2 mm/day
Average size at end of 6 weeks	- 31 mm
Average weight at end of 6 weeks	-.75 g

Our most successful grow out system consists of two 25' fiberglass raceways in a recirculating system with a sand and gravel filter and a biodisc. We are currently stocking this sytem at 2000 fish/10,000 l (.15 g/l) and in six months hope to produce 91 g/l (.7 lbs/gal).

REPRODUCTIVE PHYSIOLOGY

Efforts to induce marine fish to spawn in captivity have been hampered by a paucity of knowledge of marine teleost reproductive physiology. Studies on freshwater fish suggest that environmental cues trigger neuro-endocrine control mechanisms which in turn stimulate the production of those hormones which induce sexual maturation and spawning. The stress of capture causes a marked hypersecretion of some hormones and hyposecretion

of others and these changes persist if the fish does not acclimate to confinement. It is probable that these stress-induced changes in hormone secretion are a major cause of reproductive failure in captivity. An understanding of the effects of confinement on the reproductive cycle will be necessary for maintaining viable breeding stock for mariculture operations, and in developing techniques to artificially induce sexual maturation and spawning in fish by hormone injections. The objectives of the reproductive physiology group are: (1) To determine the sources and identities of the hormones controlling successive stages of sexual maturation and spawning in selected marine teleosts (2) To determine the laboratory conditions necessary for the normal sexual cycle of hormonal and maturational events to occur (3) To develop procedures for inducing maturation and spawning with hormone injections.

Research efforts to date have concentrated on determining the sources and identities of hormones controlling successive stages of sexual maturation in wild populations of spotted seatrout. Blood samples have been collected at regular intervals throughout the reproductive cycle and analyzed for steroid hormones.

1. Collection of blood samples

Most conventional fish capture methods are unsuitable for obtaining blood samples for steroid analysis, since the circulating levels of these hormones change rapidly after the stress of capture. From early April until the end of October 1981 spotted seatrout were caught with hook and line and bled within two minutes of capture. This rapid capture technique did not affect the circulating steroid hormone levels in these fish.

Spotted seatrout at all stages of gonadal maturation could be caught by this method except running ripe females who may not feed during the spawning period. Collecting efforts of 1982 have concentrated on obtaining running ripe female spotted seatrout at likely spawning sites with a trammel net (Photo 3). The net (1000 foot long) is set at dusk on the edge of a shallow grass flat and the fish are frightened into the net by striking the water with paddles. The effects of this capture technique on steroid hormone levels in seatrout is currently being investigated.

2. Reproductive Biology

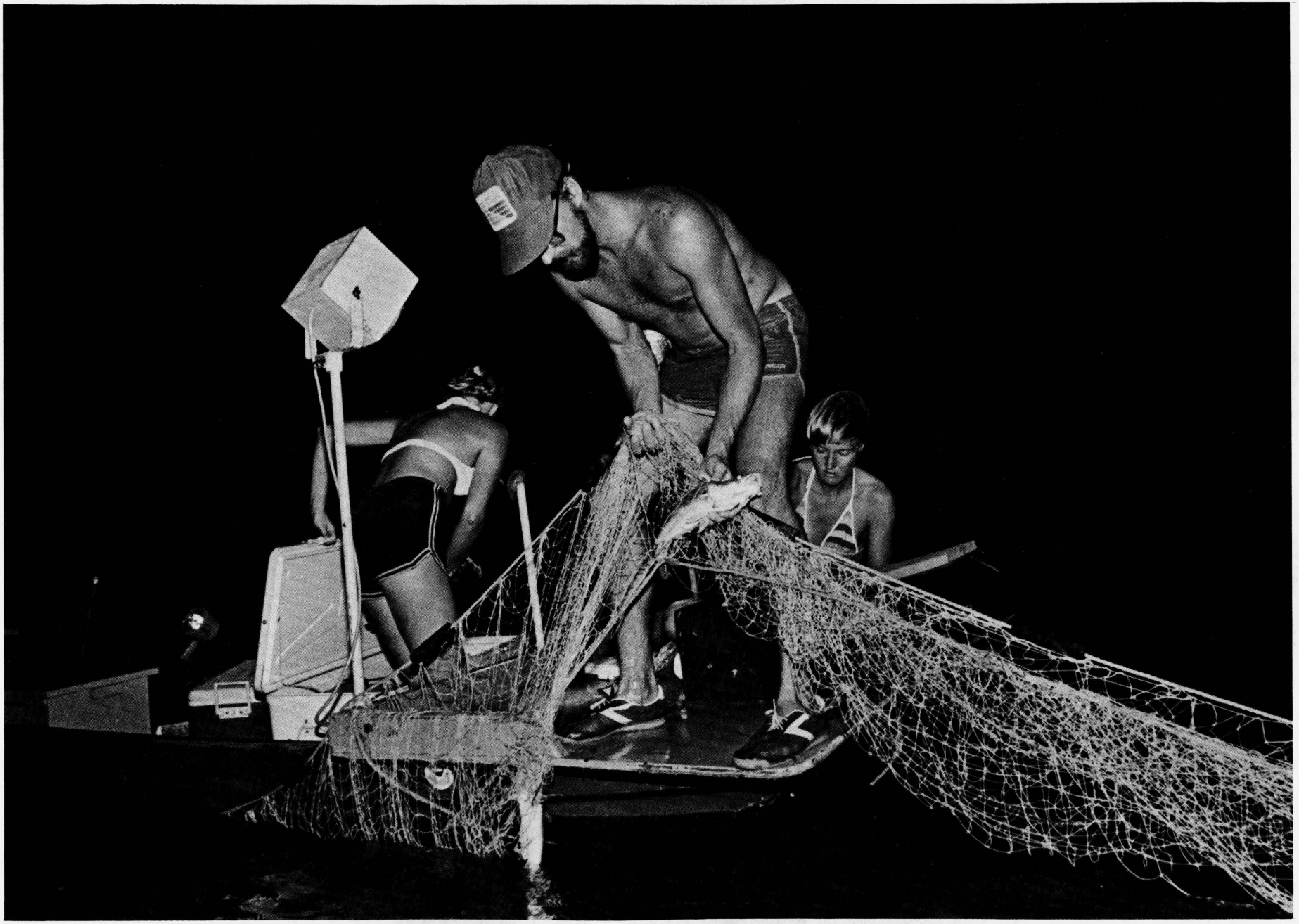
Trammel netting of spotted seatrout at their spawning sites can also provide valuable information on the reproductive biology of this species. Preliminary data indicate that spotted seatrout move into shallow grassy flats around dusk to spawn (Table 5).

Table 5. Number of running ripe female spotted seatrout caught with a trammel net on grassy flats near Hog Island during a 24-hour period in May, 1982.

Time	Number of females	Number of running ripe females
dusk	13	3
midnight	6	0
dawn	10	0
midday	0	0

Photo 3.

Trammel netting.



Three likely spawning sites at Hog Island in Redfish Bay near Aransas Pass, Texas are being regularly sampled during the 1982 spawning season. The preliminary data obtained to date suggest that peak spawning at this site occurs in April (Table 6) and that spawning is maximum during the full moon phase of the lunar cycle.

Table 6. Number of spotted seatrout caught by trammel netting near Hog Island at dusk during Spring 1982.

Date	lunar phase	Number of females	R.R. females	males	R.R. males
18 March	last quarter	3	0	1	0
3 April	1st quarter	3	2	4	3
8 April	full moon	8	5	6	6
28 April	1st quarter	8	1	3	3
18 May	last quarter	16	1	3	3
25 May	new moon	14	2	0	0
3 June	full moon	14	4	2	2
10 June	last quarter	2	0	0	0
24 June	new moon	4	0	0	0

R.R. - running ripe

3. Measurement of Steroid Hormones

Laboratory research has been directed towards developing techniques to measure steroid hormones in fish plasma.

3a. High-performance liquid chromatography:

A new high-performance liquid chromatographic (HPLC) method has been

developed (Thomas & Wofford, 1981) which measures the three corticosteroid hormones in teleosts simultaneously and enables the involvement of C21 steroids in sexual development, oocyte maturation and spawning to be easily investigated for the first time. The hormones cortisol, cortisone, corticosterone, deoxycorticosterone, 17 α-hydroxyprogesterone and progesterone can be measured in biological samples within one hour. A chromatogram of red drum plasma (Fig. 1) shows peaks which coelute with cortisol and cortisone.

A present we are attempting to adapt this method to measure the steroid hormones produced during incubations of endocrine tissues. This would enable us to determine the sources of the hormones which control successive stages of maturation in spotted seatrout. A chromatogram of the products released during incubation of spotted seatrout ovarian tissue shows several small peaks with the same retention times as the major ovarian steroids 17 β-estradiol, estriol, estrone, 17 α-hydroxyprogesterone and progesterone (Fig. 2). Thus the major ovarian steroids can be completely resolved by HPLC on a reversed-phase column. However, the present detection method (UV absorbance at 220 nm) lacks sensitivity and alternative detection methods are now being considered.

3b. Radioimmunoassay:

Sensitive radioimmunoassays (RIA) to measure the minute amounts of steroid hormones present in fish plasma are being established. RIAs for the adrenocortical hormones, cortisol and corticosterone, have been developed previously and extensively validated for their meaurement in fish blood.

Currently RIAs to measure the androgens testosterone (T), 11-keto-

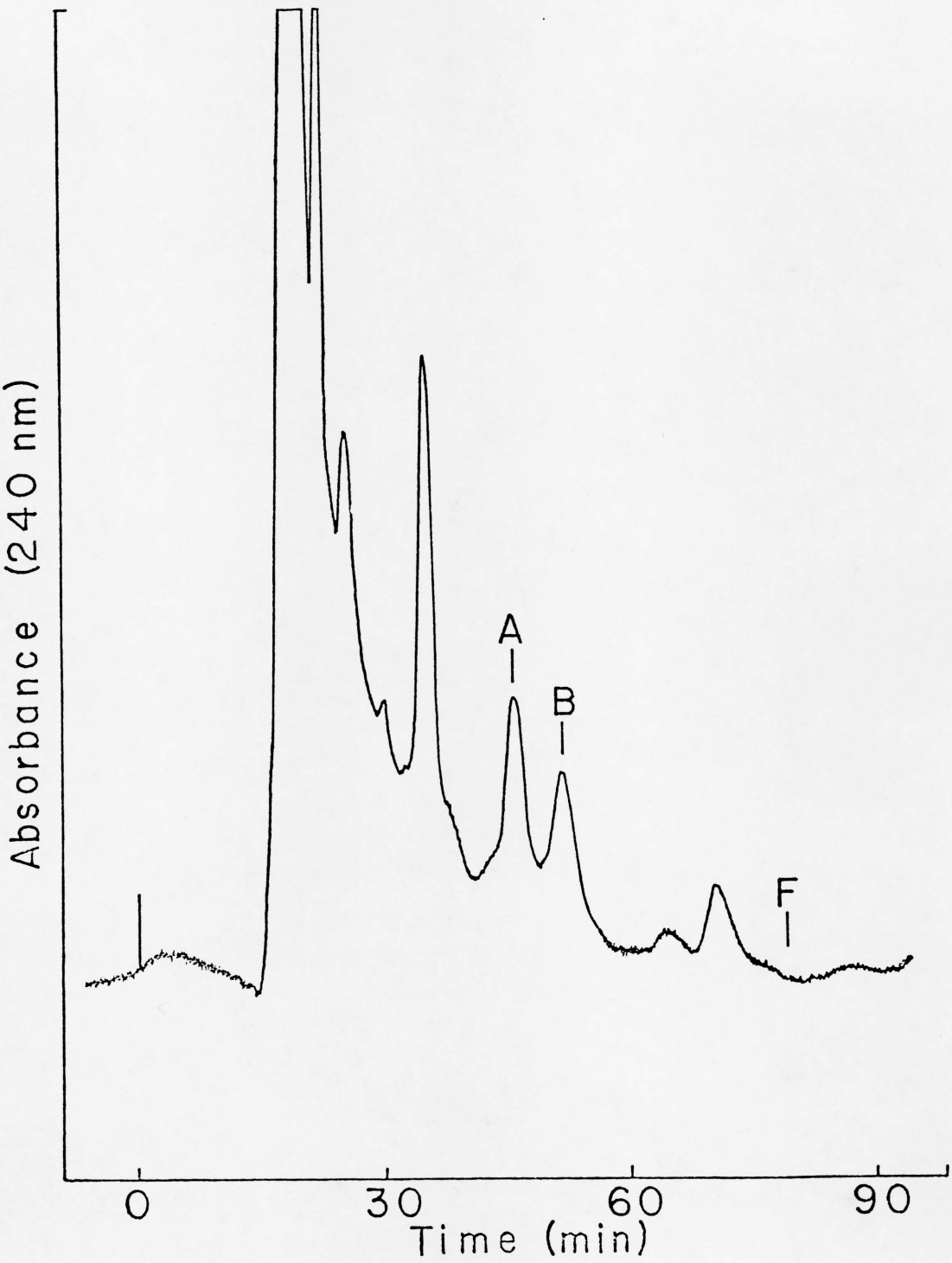


Figure 1. Chromatogram of red drum plasma extract showing cortisone (A), cortisol (B), and corticosterone (F).

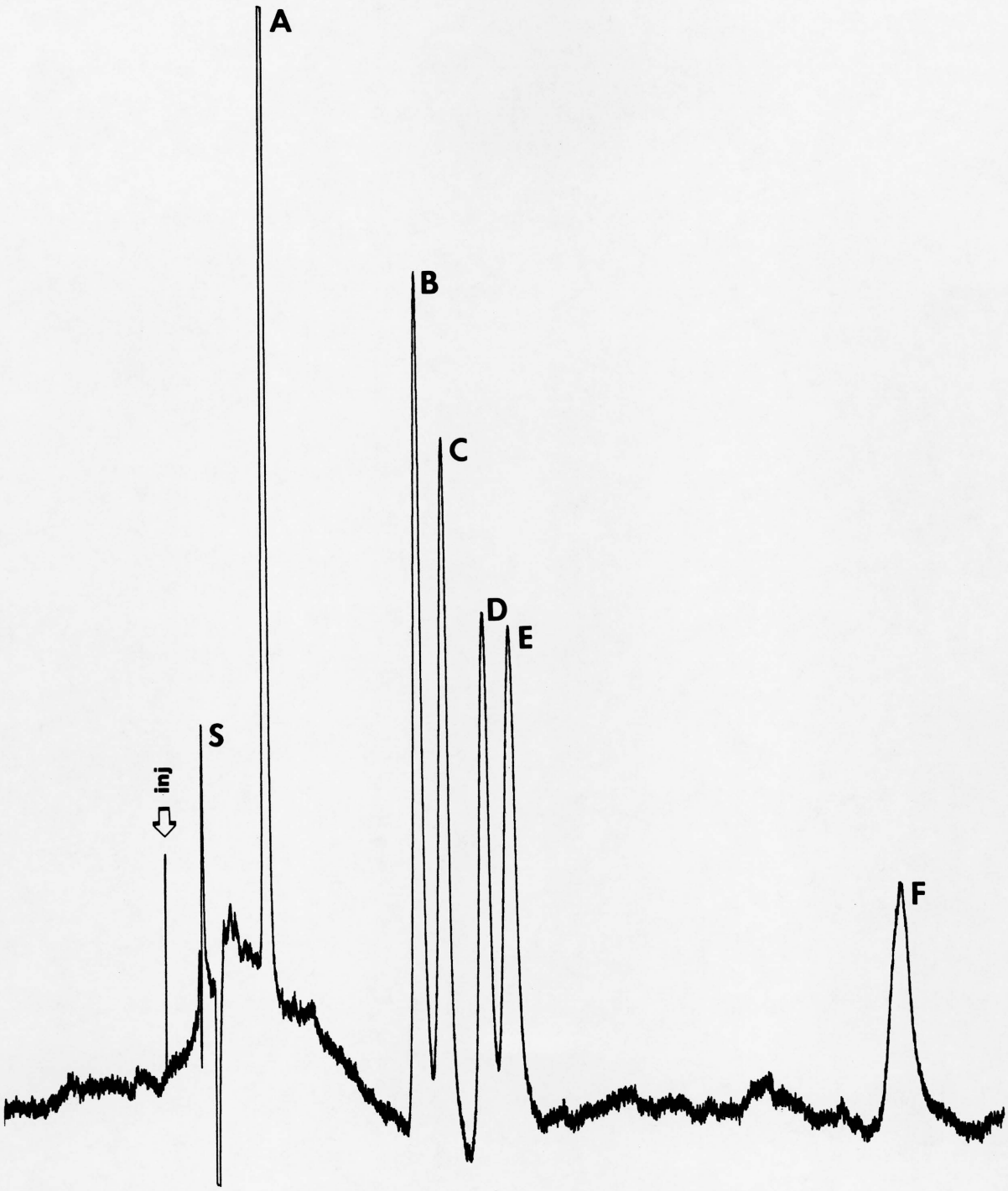


Figure 2. HPLC chromatogram of important ovarian steroids. Methanol:water (67.5:32.5), solvent system.

Key: inj, injection mark; S. solvent front; A, estriol; B. estrone; C. β-estradiol; D. 17α-hydroxyprogesterone; E. 17α-hydroxy, 20β-dihydroprogesterone; F. progesterone.

testosterone (11-KT) and 17 α, 20 β-dihydroxyprogesterone (17 α, 20 β-OHP) are being developed. During the current year RIA's for measuring these three androgens in fish blood have been established.

4. Seasonal androgen fluctuations in male fish.

Alterations in the circulating levels of T and 11-KT in male spotted seatrout were observed during the reproductive season. Highest levels of 11-KT were detected in fish blood collected during the peak spawning period in April (Fig. 3). During this early part of the 1981 spawning season mature fish had higher plasma 11-KT concentrations than running ripe individuals. 11-KT levels subsequently declined in both mature and running ripe fish to less than 2 ng/ml in July. Over 83 percent of the males collected between April and September (mean water temperature 27.2°C) were running ripe. In contrast all the fish obtained after the onset of colder weater in mid October were spent (mean temp. 20.4°C). Circulating levels of 11-KT in fish collected in October were less than 1 ng/ml. Testosterone exhibited a similar pattern of plasma fluctuations in this species during the spawning season (Fig. 4). Maximum levels (2.4 ng/ml) were detected in fish caught in April. Plasma T concentrations gradually fell during the summer and by August were less than 1 ng/ml. In September T levels further declined to 0.2 ng/ml even in running ripe fish. To date 17 α, 20β-OHP has only been measured in a few blood samples. Preliminary data suggest that there are no marked seasonal fluctuations of 17 α, 20β-OHP levels in male spotted seatrout and that plasma levels are low (less than 0.2 ng/ml).

The above results suggest that both 11-KT and T are involved in testes maturation in spotted seatrout. However, high circulating levels of these hormones do not appear to be necessary for continued sperm

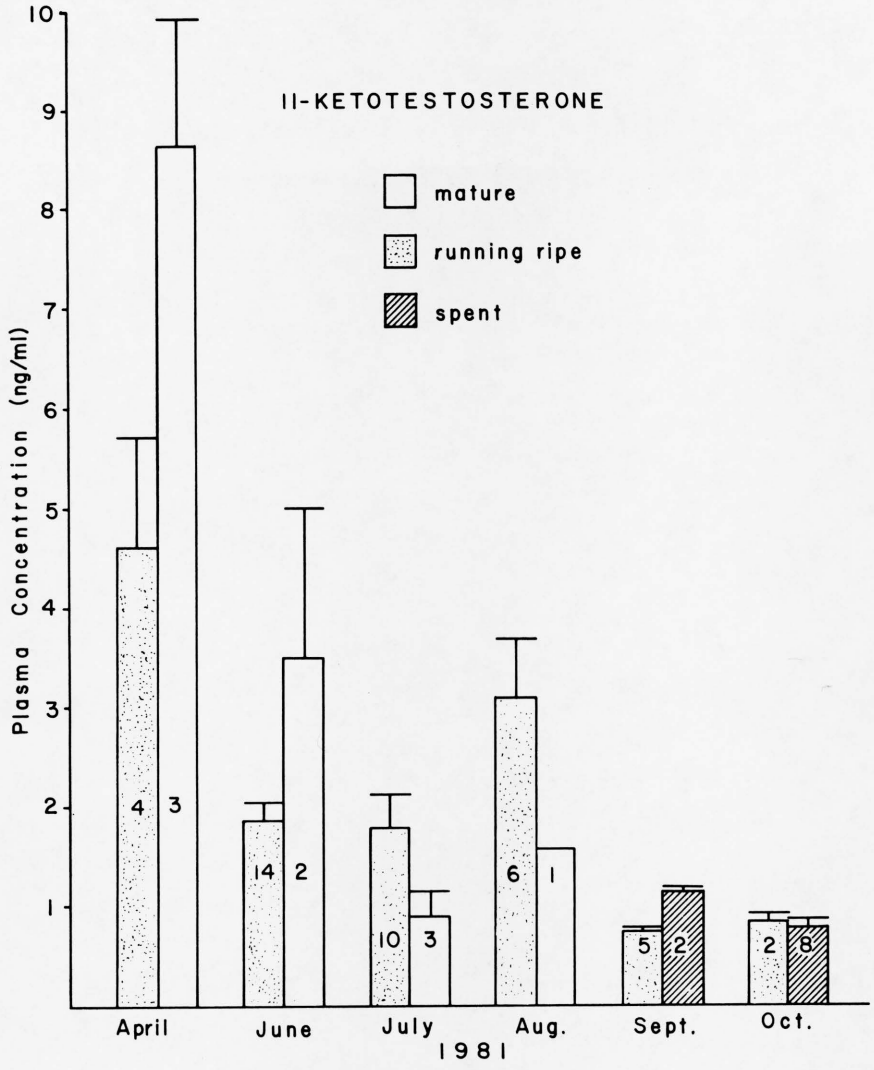


FIGURE 3. SEASONAL VARIATIONS IN PLASMA 11-KETOTESTOSTERONE LEVELS OF MATURE MALE SPOTTED SEATROUT.

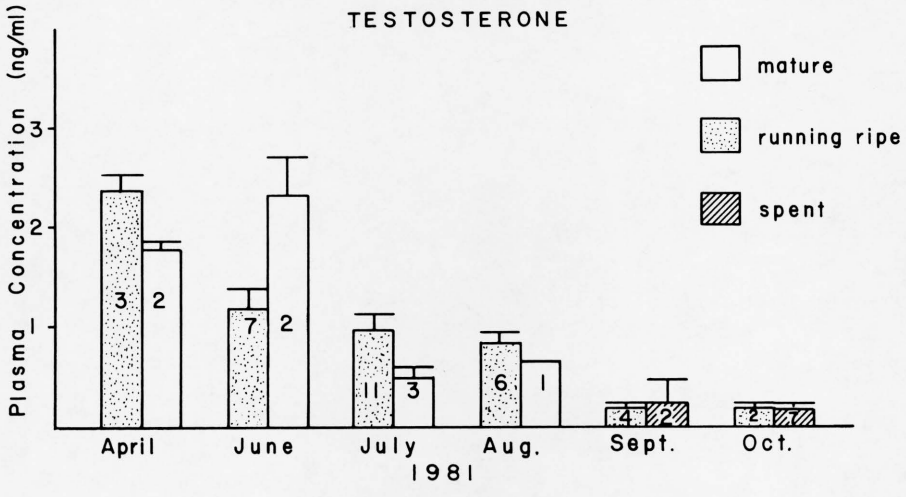


FIGURE 4. SEASONAL VARIATIONS IN PLASMA TESTOSTERONE LEVELS OF MATURE MALE SPOTTED SEATROUT.

production. Similar findings have been reported in male rainbow trout. In this species elevated 17 α, 20 β-OHP levels were associated with the production of spermatozoa. However, preliminary results that indicate that 17 α, 20β-OHP does not have a similar role in spotted seatrout. Which hormone controls sperm production in spotted seatrout is perhaps the most intriguing question which has arisen out of the current research. The search for this hormone promises to be an exciting project for 1983.

The plasma concentrations of T, 11-KT and 17 α, 20β-OHP in running ripe male spotted seatrout were only one percent of those in rainbow trout. Even lower circulating levels of these androgens were detected in the blood of running ripe male red drum caught in October 1981. Low levels of testosterone have been reported in another marine perciform found in the Gulf (Pomatomus saltatrix). The significance of these differences may soon become apparent when we investigate the reproductive physiology of other marine teleosts from Texas subtropical waters.

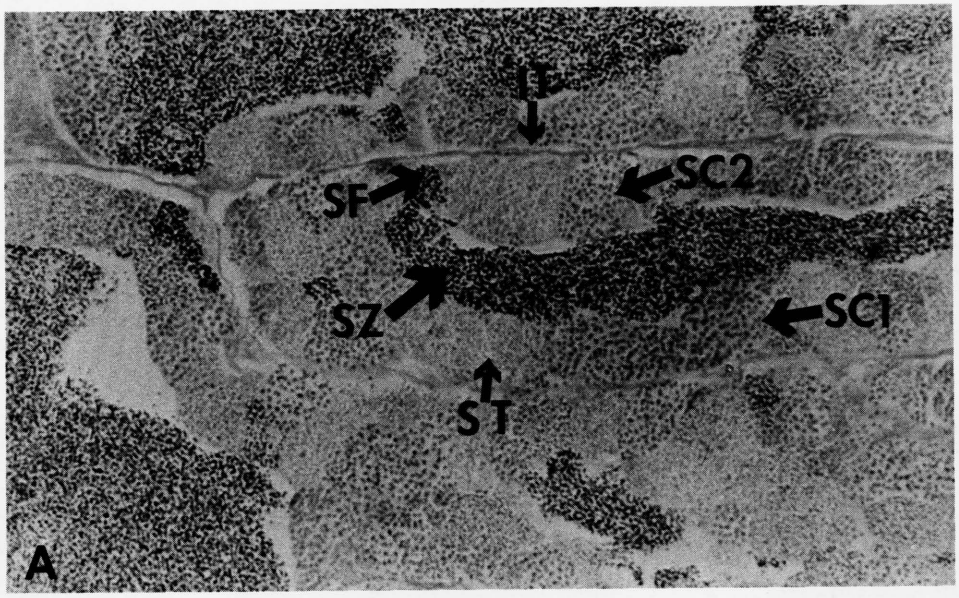
5. Gonad Histology

The gonads of every fish collected were examined histologically to detemine their exact stage of gonadal maturation. Histological examination of the testes revealed that spermatogenesis occurs along the margin of the germinal lamellae. All stages of spermatogenesis (from spermatogonal to spermatozoa) were found. The testes of running ripe males collected in April contained large numbers of primary and secondary spermatocytes, as well as spermatids and spermatozoa (Plate 2A), whereas those of running ripe individuals collected in June contained mainly spermatids and spermatozoa (Plate 2B). The lobules of running ripe fish obtained in September were filled primarily with spermatozoa (Plate 2C) and those of

Photo 4

Photomicrographs of testes of running ripe male spotted seatrout. Hematoxylin - Eosin stain, magnification 100X. A - April 5, B - June 3, C - September 5.

Key: IT, Interstitial tissue, SCI, primary spermatocyte; SC2, secondary spermatocyte, SF, seminiferous tubule; ST, spermatid; SZ spermatozoa.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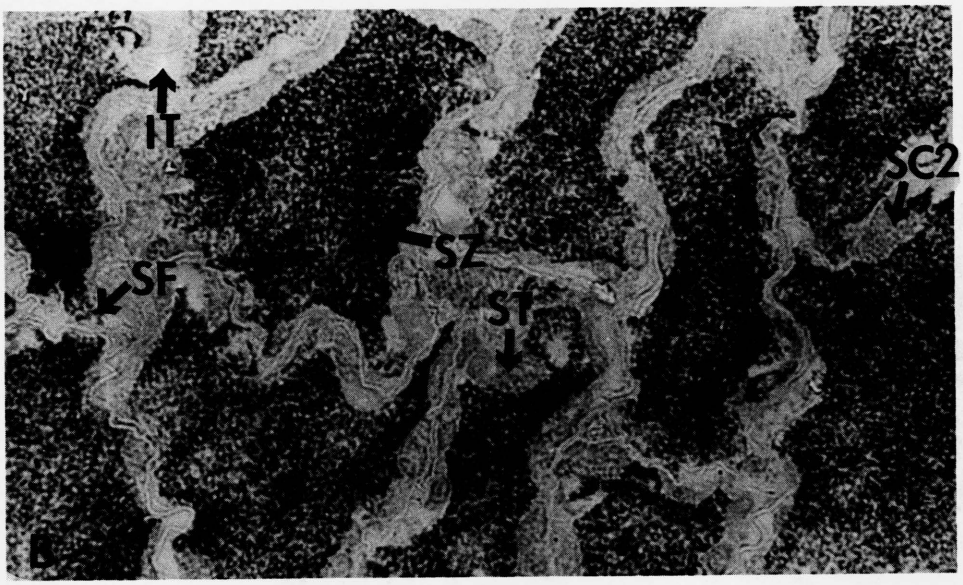
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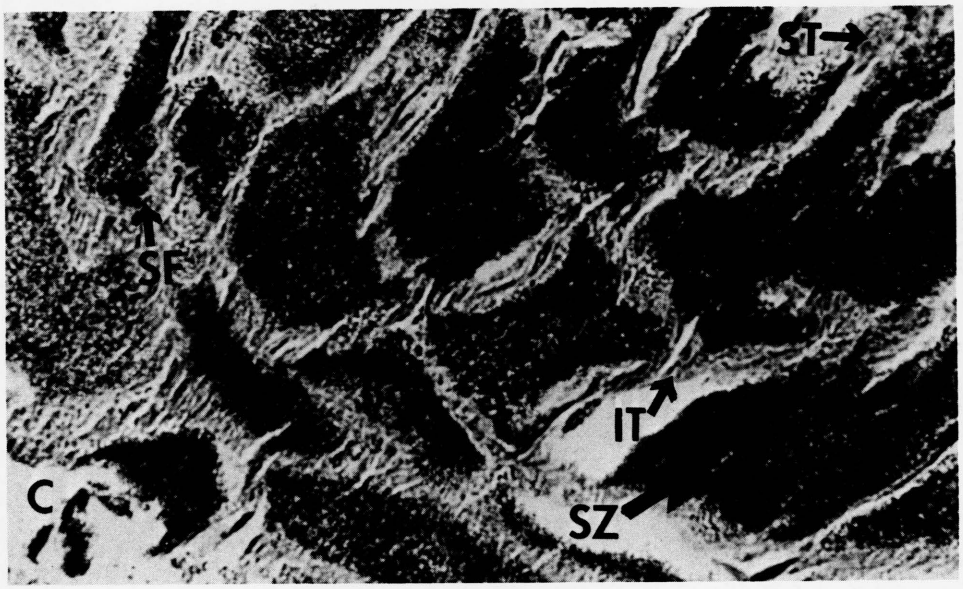
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spent individuals collected at the end of October were empty and partially collapsed.

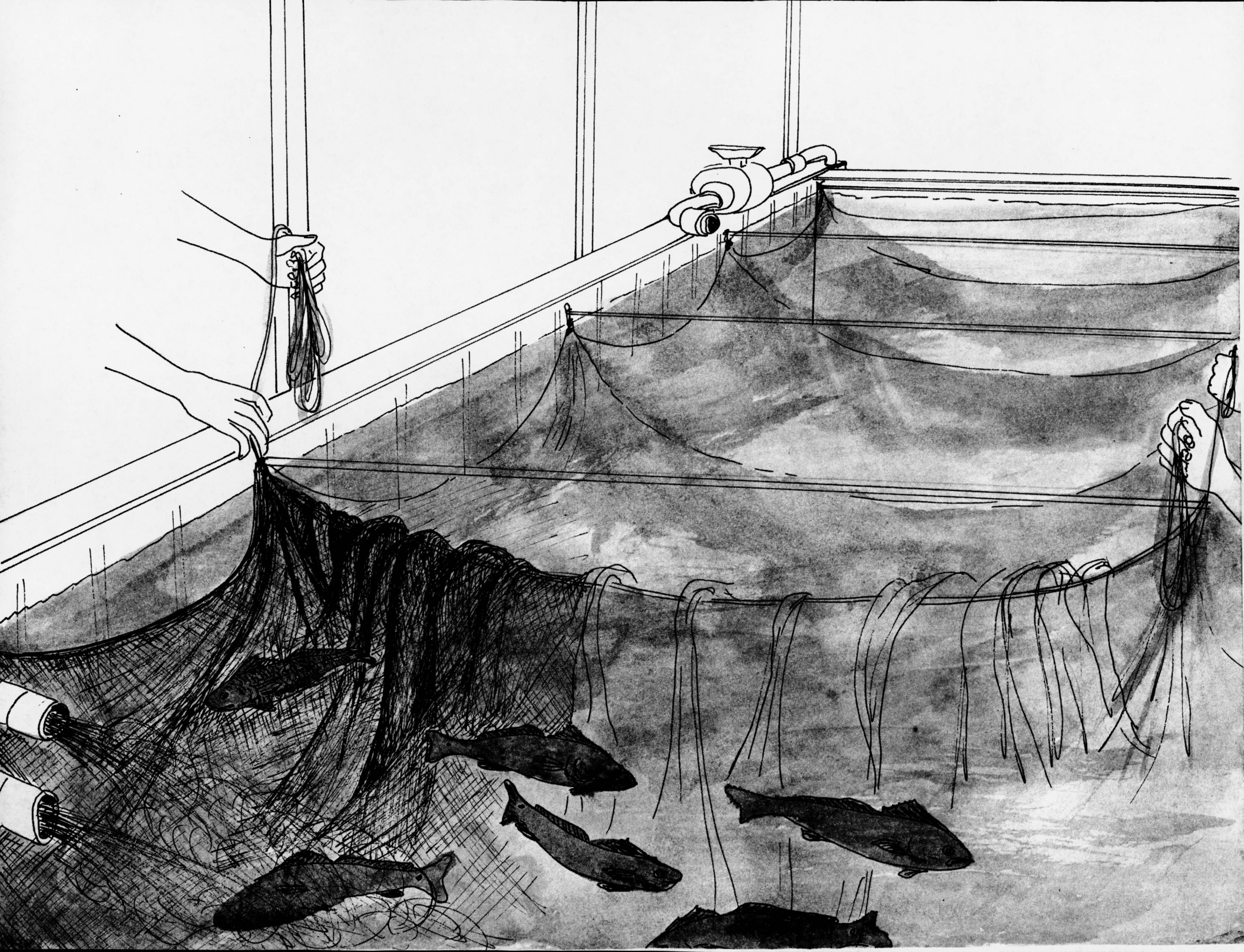
6. Measurement of gonadotropin

Gonadotropin (GTH) secreted by the piuitary gland initiates gonadal development and triggers the release of those androgens and estrogens which control each stage of gonadal maturation. Pituitary glands, obtained from immature as well as mature spotted seatrout, will be assayed for their GTH content by several heterologous fish GTH RIAs at Dr. J. Sumpter's laboratory in August 1982. These RIAs have been developed for carp and salmon GTH. Although the structure of GTH in every teleost species may be unique, it is possible that there are enough structural similarities between spotted seatrout GTH and carp GTH, for instance, that the RIA for carp GTH can be used to measure GTH in spotted seatrout. The development of an RIA for GTH would enable us to investigate pituitary and hypothalamic control of reproduction in spotted seatrout.

7. Laboratory Spawning studies

The hormonal changes which occur during the reproductive cycle in red drum artificially induced to spawn in captivity are being investigated using a specially designed experimental tank (Fig. 5). A box net, which lines the tank, can be rapidly raised in sections so that individual red drum can be quickly captured and bled. Six 20-35 lb fish can be captured from a large 30'x15'x10' tank by this technique and bled within ten minutes. This procedure does not affect plasma androgen and estrogen levels and minimizes damage to the fish which rapidly recover. From these experiments it should be possible to determine the effects of captivity on the reproductive cycle in red drum. This knowledge wil be invaluable to

Figure 5. Tank and net used for rapidly capturing and bleeding large redfish, to determine hormone levels.



determine the laboratory conditions necessary for the normal sexual cycle of hormonal and maturational events to occur (Objective 2).

FUTURE RESEARCH

In addition to the projects described above the reproductive physiology of female spotted seatrout and redfish will be investigated in 1982. RIAs for estrogens and progesterone will be developed and used to investigate the roles of these steroids in ovarian maturation. The hormonal control of egg yolk protein (vitellogenin) production in the liver and its subsequent deposition in the developing eggs will also be studied.

NUTRITION

A study was completed to determine if glucose could be removed from sea water and utilized as a nutrient source by redfish. Juvenile redfish weighing 22 to 80 g were put into sea water (salinity 34-35 ppt) which had been filtered through 1 micron filter and U.V. sterilized. We then adjusted the glucose to 1% and chloramphenicol to 20 g/ml. After 0, 15, and 30 min blood was sampled with a heparinized micropipette from the caudal artery; plasma glucose concentrations were 59 $\pm$ 1, 98 $\pm$ 5, and 124 $\pm$ 15 mg/dl, respectively. In another experiment the fish were placed in sea water with 1% glucose for 15 min, then placed in normal sea water and blood was sampled after 0, 10, 30, and 60 min. The plasma glucose concentrations were 148 $\pm$ 13, 151 $\pm$ 12, 143 $\pm$ 20, and 145 $\pm$ 7, respectively, as compared with the control group in normal sea water at 100 $\pm$ 5 mg/dl. Another group of fish was placed in sea water containing 1% radioactive glucose (4.4×10^4 dpm, α, D-[6-3H] glucose/umole) for 15 min. Blood and stomach contents were obtained to determine specific activity of glucose in plasma and

Photo 5.

Fish growth rates.

0. size at beginning of study

1. size after 57 days - fed 30% protein diet

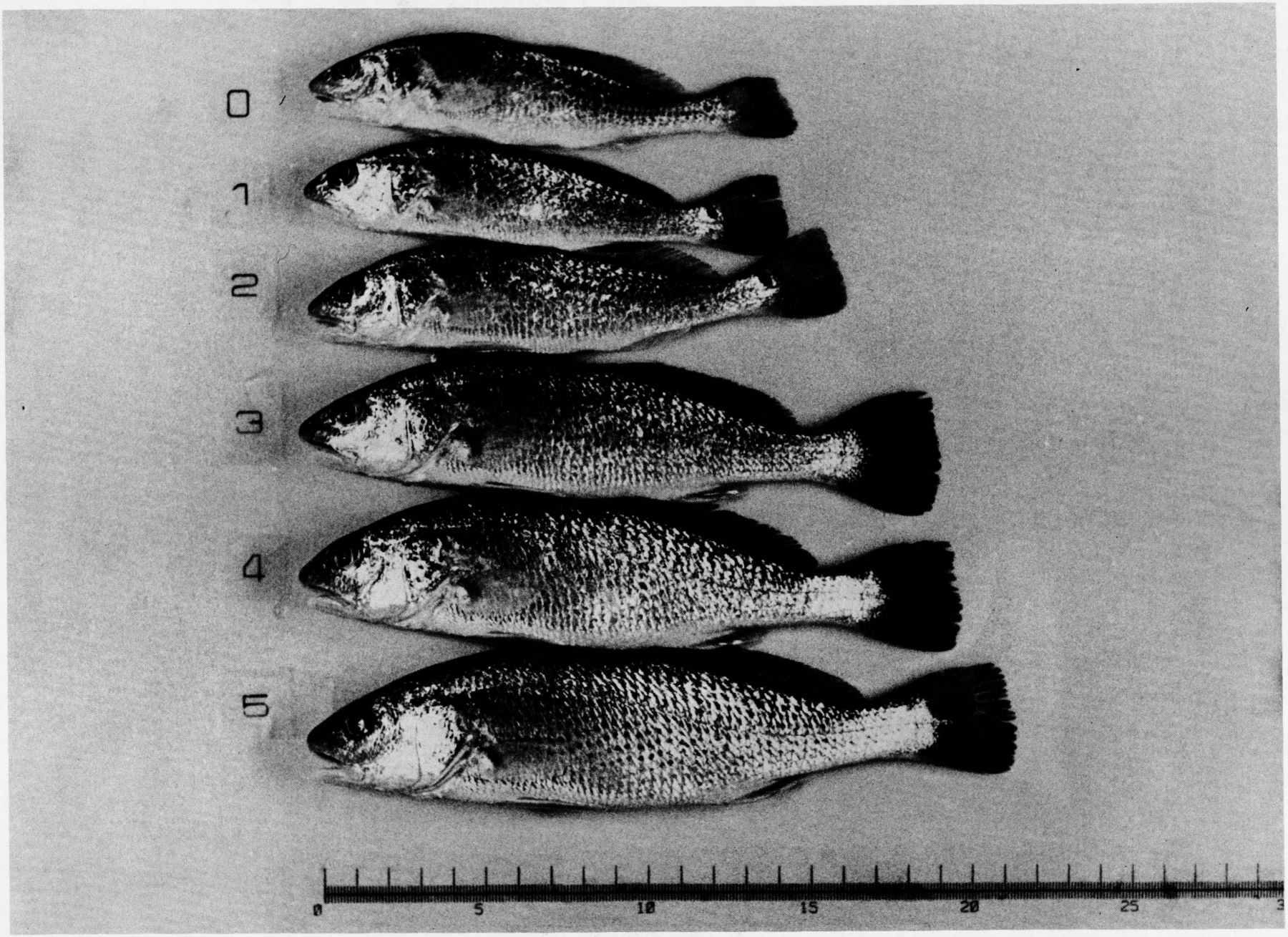
2. size after 57 days - fed 35% protein diet

3. size after 57 days - fed 40% protein diet

4. size after 57 days - fed 45% protein diet

5. size after 57 days - fed 50% protein diet

Scale in centimeters


0
1
2
3
4
5
0
5
10
15
20
25

stomach content. The plasma averaged 3330 ± 449; and the stomach contents 5985 ± 5318 dpm/umole. These results showed that fish can take up dissolved glucose from sea water.

Most of our work in diet formulation has been in the use of fisheries and agriculture by products especially fish meal, shrimp meal, and rice bran. A sequence of diets with protein concentrations of 30%, 35%, 40%, 45%, and 50% have been tested. All these diets were fortified with standard vitamin mixtures. Preliminary results indicate the 30 and 35% protein diets are not satisfactory for redfish fingerling due to the high mortality (50%) that was observed. The 40, 45, and 50% protein diets produced body weight gain of 121%, 222%, and 292% in 57 days with a 100% survival rate. The food conversion of dry weight food to wet weight fish was 1.3 to 1. The photo (Photo 5) illustrates these growth rates. A diet of 50% protein was formulated and fed to 20 day old fish (average wt. 0.1 g). After 30 days the fish had grown to an average weight of 1.96 g. This is significant because of the small size of the fish taking prepared food.

Future Work Plans

Preliminary results in amino acid utilization studies indicates S^{35} cystine is metabolized to taurine, an amino acid important in fish for maintaining blood homeostasis in various salinities. The radioactive cystine was incorporated into blood proteins 15 minutes after a peritoneal injection. After 18 hrs the radioactivity of the blood protein had increased 45 fold. Continued and expanded work in amino acid requirement and utilization is planned as well as an increased effort in diet formulation for various stages of redfish development from first feeding larval food to brood stock diets.

SCIENTIFIC PUBLICATIONS BY STAFF MEMBERS

Carr, R.S., P. Thomas & J.M. Neff. 1982. A simple spectrophotometric technique for the determination of pentachlorophenol in water. Bulletin Environmental Contamination and Toxicology 28:477-479.

Crocker, P.A., C.R. Arnold, J.A. DeBoer, and J. Holt. 1981. Preliminary evaluation of survival and growth of juvenile red drum Sciaenops ocellata, in fresh and salt water. Annual World Mariculture Society Metting, Seattle, Wash. 1981.

Fry, Brian and Connie Arnold. 1982. Rapid $^{13}C/^{12}C$ turnover during growth of brown shrimp (Penaeus aztecus). Oecologia 54(2): 200.

Holt, J., R. Godbout and C.R. Arnold. 1981. Effects of temperature and salinity on egg hatching and larval survival of red drum, Sciaenops ocellata. Fishery Bulletin 79:569-573.

Holt, J., A.G. Johnson, C.R. Arnold, W.A. Fable, Jr. and T.D. Williams. 1981. Description of eggs and larvae of laboratory reared red drum, Sciaenops ocellata. Copeia 4:751-756.

Holt, Joan and C. Arnold. 1982. Effects of temperature on early development of red drum (Sciaenops ocellata). Fifth Annual Larval Fish Conference, L.S.U. p. 83.

Holt, G. Joan and Connie Arnold (in press). Effects of ammonia and nitrite on growth and survival of red drum eggs and larvae. Sixth Annual Larval Fish Conference. Special Publication of Trans. Amer. Fish. Soc.

Holt, S. and C.R. Arnold (in press). Growth and movement of red snapper (Lutjanus campechanus) in the northwestern Gulf of Mexico. Fisheries Bull.

Holt, S.A. and G.J. Holt. Fishes killed by cold in Port Aransas, Texas, 14 January 1982. Southwestern Naturalist (submitted).

Holt, S.A., C.L. Kitting, and C.R. Arnold (in press). The distribution of young red drum (Sciaenops ocellatus) among different seagrass meadows. Proc. 6th Annual Larval Fish Conf.

Kitting, C.L., S.A. Holt, and S.H. Huh. 1982. University of Texas Marine Science Institute studies on the food webs of invertebrates and juvenile fishes concentrated among seagrasses. EOS 63(3):101 (Abstr.).

Lin, H. and C.R. Arnold. 1982. Transfer of glucose from sea water to the blood of redfish. Federation Proceedings, 41(3):352 (Abstr.).

Rabalais, Steven C., C.R. Arnold and N.S. Wohlschlag. 1981. The effects of Ixtoc I oil on the eggs and larvae of red drum (Sciaenops ocellata). Texas J. Sci. 33:33-38.

Stegman, J.J., A.M. Pajor and P. Thomas (in press). Influence of Estradiol and Testosterone on Cytochrome P-450 and Monooxygenase Activity in Immature Brook Trout, Salvelinus fontinalis. Biochemical Pharmacology.

Thomas, P. and H.W. Wofford. 1981. Simultaneous measurement of corticosteroids in teleost plasma by high-performance liquid chromatography. 3rd Symposium on Fish Physiology 76.

Thomas, P., H.W. Wofford and J.M. Neff. 1981. Biochemical stress responses of striped mullet (Mugil cephalus L.) to fluorene analogs. Aquatic Toxicology 1:329-342.

Thomas, P., M. Bally and J.M. Neff. 1982. Ascorbic acid status of mullet (Mugil cephalus Linn.) exposed to cadmium. Journal of Fish Biology 20:183-196.

Thomas, P., H.W. Wofford and J.M. Neff (in press). Effect of cadmium on glutathione content of mullet (Mugil cephalus) tissues. In: Pollution and Physiology of Marine Organisms. Eds. A. Calabrese, F.P. Thurberg, F.J. Vernberg, and W.B. Vernberg. Academic Press, N.Y.

Thomas, P., N.J. Brown and C.R. Arnold (in press). Seasonal variations of plasma androgens and gonad histology in male spotted seatrout, Cynoscion nebulosus (Family: Sciaenidae). Proceedings 2nd International Symposium on Reproductive Physiology of Fish.

Thomas, P. 1982. Effect of cadmium exposure on plasma cortisol levels and carbohydrate metabolism in mullet (Mugil cephalus). Journal of Endocrinology, Suppl. 94: 35 P.

Yoshiyama, R.M., J. Holt, S. Holt, R. Godbout and D.E. Wohlschlag. 1982. Abundance and distribution patterns of demersal fishes on the South Texas Outer Continental Shelf: A statistical description. Contr. Mar. Sci. 25.

PRESENTATIONS BY STAFF MEMBERS

1981 - 1982

"Simultaneous measurement of corticosteroids in teleost plasma by high-performance liquid chromatography" by Peter Thomas at the 3rd Symposium on Fish Physiology, Bangor, United Kingdom in September, 1981.

"Seasonal variations of plasma androgens and gonad histology in male spotted seatrout, Cynscion nebulosus (Family: Sciaenidae)" by Peter Thomas at 2nd International Symposium on the Reproductive Physiology of Fish, Wageningen, The Netherlands in August, 1982.

"The distribution of young red drum (Sciaenops ocellatus) among different seagrass meadows" by Scott Holt at the 6th Annual Larval Fish Conference of the American Fisheries Society Meeting in Solomons, Md. in March, 1982.

"Transfer of glucose from sea water to the blood of redfish" at the Annual Meeting of the American Institute of Nutrition in New Orleans, La., by Huang Sheng Lin, in April, 1982.

"Effects of ammonia and nitrite on growth and survival of red drum early life stages" by G. Joan Holt at the Sixth Annual Larval Fish Conference, Solomons, Maryland in March, 1982.

"South Texas Continental Shelf invertebrate epifauna: Abundance and distribution" by G. Joan Holt and Scott A. Holt at the AGU-ASLO Joint Oceanographic Meeting, San Antonio, Texas in February, 1982.

TECHNICAL COURSES

A Fish Disease short course at Mississippi State University was attended by Nancy Wohlschlag in May, 1982.

Mariculture: Culture of Marine Invertebrates for research purposes was attended by Wen Lee.